CONSERVATION MANAGEMENT OF NATIVE BONNEVILLE CUTTHROAT TROUT (ONCORHYNCHUS CLARKI UTAH) IN SOUTHERN UTAH

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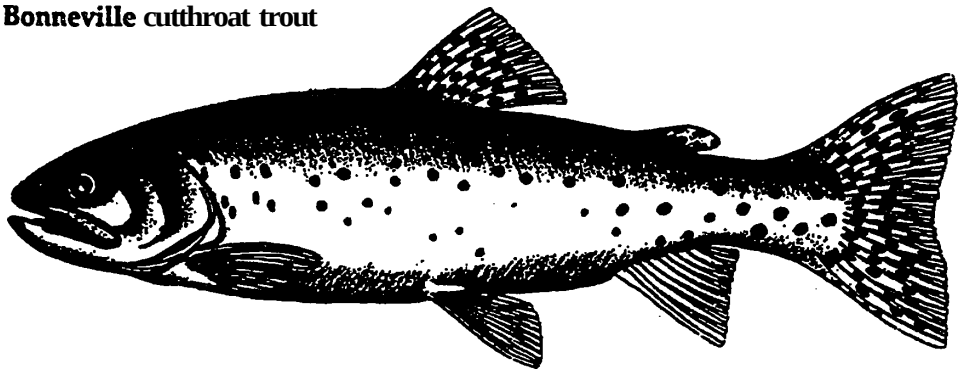
Bonneville cutthroat trout



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ABSTRACT

Active management of native Bonneville cutthroat trout (Oncorhynchus clarki utah)(BCT) began in southern Utah in 1977 when only three small populations of the subspecies were known to exist, occupying <8 km of stream. Management included transplant of individuals from genetically pure populations, identification of additional remnant populations, development of a wild brood stock, and actions to protect and improve cutthroat trout habitat. Work in southern Utah was limited to the Sevier and Virgin river drainages. By 1995, available stream habitat had increased to >140 km and included 21 streams. Estimated densities from 1994-1995 surveys of Age 1 and older BCT ranged from 118 to 546 fish per km, and biomass estimates ranged from 8 to 64 kg per ha. Numbers of BCT are expected to continue to increase as introduced populations colonize recently renovated areas. Potential threats to BCT populations are discussed in relation to problems that caused historic declines in abundance prior to 1977.

INTRODUCTION

The Bonneville cutthroat trout (Oncorhynchus clarki utah)(BCT) is the only trout native to the Great Basin in Utah. Within the eastern portion of the Great Basin, this subspecies once occupied ancient Lake Bonneville and was abundant throughout the Bonneville basin when early settlers first arrived in the inter-mountain west. Numbers of BCT rapidly declined in the late 1800's and early 1900's as a result of habitat modifications, introduction of nonnative fishes, and over-harvest (Cope 1955, Hickman and Duff 1978, May et al. 1978, Duff 1988, Behnke 1992). In particular, native trout were displaced and hybridized by widespread introductions of

rainbow trout (*Oncorhynchus mykiss*) and Yellowstone cutthroat trout (*O. c. bouvieri*). By 1955, it was feared that BCT might be extinct (Cope 1955). Nevertheless, a few remnant populations were reported in the 1970's after close examination of isolated streams in remote locations. Behnke (1976) identified a number of remnant populations in Utah, including three in southern Utah that he recommended be used to establish new populations in other areas.

Remnant populations in southern Utah were found in Birch Creek, a small headwater stream in the Beaver River drainage, and Reservoir and Water canyons in the Virgin River drainage which is part of the lower Colorado River basin just outside of the Bonneville basin. It was uncertain if these latter two populations occurred naturally in the Virgin River drainage or were introduced by very early settlers (Behnke 1976 and 1992). In 1977, trout from these three populations were restricted to <8 km of stream.

Attention was focused on BCT after the U.S. Fish and Wildlife Service considered them as a candidate species for federal listing under the Endangered Species Act and concern mounted over the condition of the Birch Creek population (Bureau of Land Management 1976). The State of Utah, Division of Wildlife Resources (UDWR) initiated management actions to expand the range of BCT by transplanting individuals from the Birch Creek population in 1977. Shortly thereafter, several more remnant populations from the Bonneville basin were

recorded (Hickman and Duff 1978). By 1988, 40 BCT populations were documented in the states of Utah, Nevada, Wyoming, and Idaho (Duff 1988).

Work in southern Utah was confined to the Sevier River and Virgin River drainages (Figure 1). The Beaver River, although a fairly discrete drainage, is a major sub-basin of the Sevier River. Other west desert drainages of southern Utah are also within the historic range of BCT but have limited trout habitat and remnant populations have not been reported from these areas. The objective of this report is to describe management efforts for BCT in southern Utah. We evaluated abundance and distribution in all known BCT populations during 1994-1995 to determine current status (Hepworth et al. 1997). In addition, we report on land management actions that have taken place and were of significance in altering or protecting habitat for this fish.

This report deals primarily with "conservation populations" of native cutthroat trout designated to protect and preserve genetically and geographically distinct cutthroat trout subspecies as described by Schmidt et al. 1995. Conservation populations are distinguished from "sportfishing populations," where sport fish management and recreational fishing are the major objectives.

METHODS

Status of Populations 1994-1995

All known BCT populations in southern Utah were sampled during 1994-1995 using a backpack electrofisher (Hepworth, et al. 1997). Surveys were conducted when stream conditions allowed effective sampling. We avoided periods when flows were high, turbidity made visibility difficult, or streams were partially frozen. A minimum of two, 161-m (0.1-mile) stations were electrofished on primary streams (defined as the highest order stream in an area that contained BCT). A minimum of one station was electrofished on primary stream tributaries. Stations included habitat representative of the stream or stream section. One electrofishing pass was made through a station, moving upstream, and we attempted to collect all BCT except young-of-the-year (Y-O-Y). Measurements of individual fish lengths (TL) were taken on all BCT collected. Y-O-Y were observed from midsummer through fall and were smaller than about 76 mm (TL). Y-O-Y were noted as present or absent. Also recorded was the number of larger (>76 mm TL) BCT observed but not collected, and that number was added to the number collected to estimate minimum population of Age 1 and older BCT. Previous estimates of minimum population based on one pass were similar to population estimates made using the removal method (Zippen 1956).

Individual fish weight was estimated using the

relationship: Log(Weight) = -4.91367 + 2.95756 Log(Length); the model was based on data from 373 BCT from six small streams in southern Utah prior to 1994. We tested for significant differences between the populations used to calculate the length/weight model (Dunn and Clark 1974). There was a significant difference between the individual regressions, but we used the pooled model to estimate weights and biomass because maximum variation between estimates from pooled and individual regressions was only 2 kg per ha.

A minimum of 10 random stream width measurements (wetted channel) were taken at each station to calculate surface area. Trout standing crop was calculated using estimates of minimum population of Age 1 and older fish and mean weights.

We also electrofished outside designated sampling stations to determine the distribution (upstream and downstream range) of BCT in some streams. Reaches where BCT were observed was classified as "occupied" habitat. "Available" habitat included occupied areas as well as areas where we thought BCT would eventually become established. Stream lengths were taken from U.S. Geological Survey 7.5-minute series topographical maps.

To describe changes and trends in BCT populations, we compared recent abundance and distribution data to past information from UDWR files. We also made some comparisons with data for nonnative rainbow trout at several locations where they were later removed prior to establishing BCT by transplants. Survey methods used prior to 1994 were similar to

those listed above. We made visual observations to supplement formal surveys at some BCT streams, and reviewed related work such as collections for transplants. Important land management actions that influenced BCT habitat were reported for each stream.

General Management 1977-1995

Pure populations of BCT were identified by at least two independent reviews using different methods: meristic characteristics along with fish stocking records, electrophoresis, and mitochondria1 DNA analysis (Behnke 1976 and personal communication, Thompson 1987, Martin and Shiozawa 1982, Martin et al. 1985, Shiozawa and Evans 1993, Shiozawa and Evans 1994a, Shiozawa and Evans 1994b).

BCT populations were established by transplanting fish from remnant populations into other area streams. Transplants were made with standard hatchery transport trucks or small oxygenated water coolers, Water coolers and medical-size oxygen bottles were used with backpacks or with horses to complete work in remote locations, Streams scheduled for transplants were renovated with rotenone to remove nonnative trouts. After the first two projects, it became standard practice to treat streams with rotenone on two successive years to insure complete removal of fish. With three exceptions, nonnative trouts were the only fishes present in renovated

streams. Provisions were made to protect or replace other native fish species in areas where they occurred.

Criteria that were used to select transplant sites included (1) geographic location and drainage, (2) the ability of the new area to support trout, (3) avoidance of public controversy, (4) the feasibility of removing all nonnative trout, (5) isolation of the new introduction site from potential re-contamination by nonnative fishes, and (6) preference for new areas to be located on public lands. In addition, in recent years it became more important to maximize the number of stream miles gained from individual projects. Small projects have become less practical because of the difficulty and time required to attain environmental clearances for rotenone treatments and agency approvals to introduce fish.

We limited the number of fish taken for transplants to protect donor populations. The number of fish transplanted was based on total donor population size and the ability of the population to replenish itself. We limited the size of fish transplanted, leaving behind Y-O-Y and larger adults. Also, a portion of each donor stream was set aside as a refuge area from which transplanted fish were not collected. In total, <20% of a donor population was transplanted in any single year. With the exception of two of the smaller streams that received transplants, all primary streams received a minimum of 100 transplanted fish (which included the sum of introductions into tributary streams).

A BCT brood stock was developed similar to recommendations made for other subspecies of cutthroat trout (U.S. Fish and Wildlife Service 1983a and 1993, Behnke 1992). As part of the effort to develop a brood stock of BCT, a new population of trout was first established in Pine Creek with transplants from the original three remnant southern Utah populations. The Pine Creek introduction increased total fish numbers and made fish available for introduction into a reservoir, where fish size and egg production could be increased. When mature trout from the reservoir attempted to spawn in a tributary stream, they were trapped to procure and fertilize eggs for culture and management purposes. Standards for disease certification were maintained during all stages of brood stock development (Colorado River Wildlife Council 1995).

RESULTS

Population Evaluations

By 1995, remnant BCT populations were known to exist in six streams in southern Utah, and had been transplanted into an additional eight primary streams (Hepworth et al. 1997)(Figure 1 and Table 1 . Since 1977, new discoveries of remnant populations from southern Utah were made from Deep Creek (Behnke 1976, Martin and Shiozawa 1982), the North Fork of North Creek (Martin and Shiozawa 1982), and Ranch Creek (this report and D. K. Shiozawa, Brigham Young University, personal

communication). Cutthroat trout from Birch Creek were transplanted into five additional streams, counting tributaries. Fish from Reservoir and Water canyons were each transplanted in three additional streams. A mixed population from Water and Reservoir canyons was established in the main stem of Leeds Creek and one of its tributaries, Pig Creek.

Southern Utah streams containing BCT increased from <8 km of occupied habitat in 1977 to 140.5 km of available habitat and >57 km of occupied habitat by 1995 (Table 2). Immediately following the drought in 1977, known numbers of BCT in southern Utah probably declined to <2000 fish. Currently, we estimate >14,000 BCT in southern Utah streams, plus two reservoir populations. Numbers of trout should more than double again as recent introductions expand to fill available stream habitat. Within several years following transplants, introduced trout were successfully established in all new locations. All transplanted populations remained successful through 1995, with the exception of Sam Stowe Creek. We found cutthroat trout in Sam Stowe Creek to be hybridized with rainbow trout. This was probably a result of highway construction or changes in irrigation structures on the stream that removed barriers which had previously isolated Sam Stowe Creek from Clear Creek. The cutthroat trout introduction into Sam Stowe Creek was initially successful and a genetically pure population of BCT lasted from 1977 to at least 1984 as indicated by a survey at that time.

Estimated densities of Age 1 and older BCT ranged from 118

to 546 fish per km, and biomass estimates ranged from 8 to 64 kg per ha (Table 2). Several age-groups of BCT were collected at most locations, with older fish ranging up to 305 mm TL. Most fish collected were between 100 and 250 mm TL. The highest biomass estimates for Age 1 and older BCT were for the Leeds Creek drainage, where it ranged from 53 to 64 kg per ha. The lowest estimate was Water Canyon, where habitat was <1 km during dry years. BCT densities (trout per km) were higher during 'recent than past sampling at four streams (Table 3). Recent biomass estimates were intermediate between estimates for past years at two waters and lower than any previous estimates at two of the streams.

Population data were also available for two streams that contained rainbow trout prior to BCT introductions (Table 4). Leap Creek had an estimated population of 360 rainbow trout per km in 1983, compared to 304 and 130 BCT per km in 1989 and 1995, respectively. Population estimates for Leeds Creek were 646 rainbow trout per km in 1980 and 193 BCT per km in 1995. Estimates of biomass for these two streams were also less for BCT populations compared to rainbow trout, but mean lengths for BCT were substantially greater than those recorded for rainbow trout. In all the streams that we surveyed during 1994-1995, the greatest biomass (kg per ha) was from the hybridized population in Sam Stowe Creek (Table 2).

Brood Stock Development

A mixed BCT population was established in Pine Creek with transplants from Reservoir Canyon, Water Canyon, and Birch Creek. A total of 245 trout were transplanted into Pine Creek in 1980 (Table 1) as the initial step in creating a wild source of native brood fish from southern Utah.

An early set back in brood stock development occurred when several rainbow trout were found in a headwater spring in Pine Creek shortly after BCT were introduced. The headwater area was the only location along the stream where rainbow trout were found when the stream was first treated with rotenone. The rest of the stream had contained brown trout (*Salmo trutta*). The upper one-fourth of Pine Creek was retreated on consecutive years. Salvaged cutthroat trout from the treated area and from the lower end of the stream were moved back into the upper stream following treatment. After the second treatment project, most of the stream's length was electrofished for each of the next 5 years without finding any evidence of rainbow trout. This was done in part to collect samples for disease certification as part of the brood fish project, but it also allowed the stream to be inspected for the presence of nonnative trouts and hybrids. D. K. Shiozawa (personal communication) studied trout from the lower one-third of Pine Creek in 1990 using DNA methods (capable of detecting maternal introgression at the 2% level) and failed to find any

indication of rainbow trout hybridization.

A total of 714 BCT from Pine Creek were transplanted into Manning Meadow Reservoir at the head end of the Manning Creek drainage in 1990 and 1991 (Table 1). Eggs were taken for the first time at Manning Meadow Reservoir in 1992. Yearly (1992-1994) totals of 19,000, 61,000, and 57,000 eggs were collected from the original transplanted trout and successfully raised in UDWR fish hatcheries. A total of 177,000 eggs were taken in 1995 from both the progeny of the transplanted fish and some of the remaining transplants.

Habitat Status

Efforts were made to correct habitat problems on BCT streams (Table 5). In-stream structures were installed under the direction of the U. S. Forest Service (USFS) and the Bureau of Land Management (BLM), and consisted of log or rock drop structures and bank revetments. Structures reduced stream velocities and erosion, and thereby, encouraged natural rebuilding and re-vegetation of stream banks, as well as directly providing pools and cover for trout. Fences were constructed in association with in-stream structures to protect riparian areas from livestock grazing. Some streams, such as Leap Creek, South Ash Creek, and Leeds Creek, had excellent riparian areas, good trout habitat, and did not require habitat improvement work. Road closures and road relocations at Birch

Creek, Pine Creek, and Water Canyon Creek were made to reduce vehicle use along streams, reduce erosion, and help stabilize stream banks. The road closure to Leap Creek was the result of Wilderness designation, but further isolated the stream and prevented vehicle access and associated impacts.

Fish barriers were constructed or enhanced by the USFS on the North Fork of North Creek and Threemile Creek, by the BLM on Birch Creek, and by UDWR on Manning Creek and Sam Stowe Creek (Table 5). The barrier on Birch Creek gave additional protection to a remnant population that was already isolated by seasonal dewatering of the lower stream reaches. The barriers on Threemile Creek and Manning Creek were part of projects which established new BCT populations in areas which were also partially isolated by seasonal dewatering, Construction of a barrier on the North Fork of North Creek increased available habitat for a remnant population from 2.3 to 8.8 km of primary stream and added 4.3 km of tributary stream (Pole Creek). The barrier on Sam Stowe Creek was reconstructed in 1996 in anticipation of renovating the stream to restore a pure BCT population,

Changes in land and water uses, ownership, and other land management resource designations also had positive impacts on BCT (Table 5). The state of Utah, Division of Parks and Recreation purchased property on the lower end of Sam Stowe Creek in 1986 as part of a larger state park acquisition that converted the entire stream length to public lands. Threemile

Creek was designated as a riparian management demonstration area in 1989 by the USFS and BLM, and was subsequently recommended as a transplant site for native cutthroat trout. The UDWR purchased water rights, including rights to Manning Meadow Reservoir and Barney Reservoir in 1988, along with acquisition of property on the lower end of the stream. That portion of the stream that retains perennial surface flows is now entirely located on state, BLM, and USFS administered lands with in-stream water rights decreed to UDWR in 1991. Barney Reservoir was constructed in 1990 at a size of 7.3 surface ha and Manning Meadow Reservoir is managed at a full pool of 22 surface ha. The Pine Valley Wilderness Area was established in 1984 and entirely encompasses Reservoir Canyon and also includes the headwaters of Water Canyon, Leap, Mill, and Harmon creeks. The USFS finalized forest management plans in 1986 and designated a number of BCT streams for "emphasis on fish habitat improvement" (Sam Stowe Creek, Manning Creek, Birch Creek, North Fork North Creek, Pine Creek, and Water Canyon Creek) and for "intensive riparian management" (Leap Creek, South Ash Creek, and Leeds Creek).

DISCUSSION

Drainages and Fish Distributions

In general, we tried to maintain native trout populations within defined drainages and avoided inter-drainage transplants

(Figure 1 and Table 1). The Sevier River and Beaver River along with that portion of the Virgin River drainage containing BCT are most closely associated with what had been the southeast arm of ancient Lake Bonneville, which represents only a portion of the total historic range of BCT. Behnke (1992) described the origin of BCT as polyphyletic with three divergent groups present today (Bear River, Snake Valley, and the remainder of the Bonneville basin which includes southern Utah) that should be managed to maintain their geographic integrity. Native trout in southern Utah occurred historically in naturally fragmented habitats and can be viewed as occurring on mountain ranges isolated from each other by desert valleys. Even those valleys with perennial streams offer only limited connectivity between mountain streams because of naturally dry stream segments, man-caused dewatering, other physical barriers, and environments that are inimical to trout survival.

Aside from the development of a BCT brood stock, populations within the Sevier River and Virgin River drainages were transplanted within same drainages (Figure 1 and Table 1). No transplants were made from the Bonneville basin into the Virgin River drainage. In two cases, trout were transplanted from the Beaver River portion of the Sevier River drainage (Birch Creek) to tributaries in the main stem of the drainage (Sam Stowe Creek and Threemile Creek). In these situations, Birch Creek trout were moved to mountain ranges directly to the north and south of the Tushar Mountains which the Beaver River

drains. Pine Creek, in the Beaver River drainage, was used to develop brood stock and received a mixed introduction of BCT from Birch Creek and the Virgin River drainage. Pine Creek was chosen, in part, because of its isolation from other streams. Pine Creek's natural connection with the lower end of the Beaver River consists of >40 km of dry stream channel.

Manning Creek, also used to develop brood stock, is another example of stream isolation. Although the mouth of the canyon where the stream enters the Sevier River valley is <8 km from the Sevier River, surface runoff reaches the river only during high spring flows. Stream flows usually sink into a broad alluvial deposit outside of the canyon mouth. Shiozawa and Evans (1994b) concluded from DNA analysis that less gene flow occurred between populations of Utah's native trout than has commonly been thought, even considering when streams were more interconnected prior to man's impacts.

Deep and Ranch creeks contain the only potentially pure remnant BCT populations known from the Sevier River drainage, outside of the Beaver River basin (Figure 1 and Table 1). Behnke (1976) examined a number of fish supposedly from Deep Creek and concluded that they were hybridized, to a small extent, with rainbow trout. However, some confusion occurred with labeling when the first samples were sent for identification, and the results were confounded with fish from three streams (B.E. May, personal communication). Additional electrophoretic and DNA analysis of trout from Deep Creek

(Martin and Shiozawa 1982 and D. K. Shiozawa personal communication) showed no sign of rainbow trout introgression. Future plans should include transplanting populations from Deep and Ranch creeks.

The discovery of BCT in the Virgin River drainage creates questions over the origin of these fish and subsequent management actions. Although the Colorado River cutthroat trout (*O. c. pleuriticus*) has been suggested for management in this area, it is not an appropriate fish for introduction even though the Virgin River is part of the Colorado River drainage. The natural distribution of Colorado River cutthroat trout is >500 km removed from the Virgin River drainage, separated by the Grand Canyon (Behnke 1992). The Virgin River's native fish fauna is derived from the lower Colorado River basin. If trout had evolved in this system from the Colorado River drainage, the closest natural source would have been the Gila trout (*Oncorhynchus gilae gilae*) in central Arizona.

Behnke (1976 and 1992) discussed the likelihood of BCT occurring naturally in the Virgin River drainage and presented arguments for and against this possibility. Early residents testified that cutthroat trout were present in the Santa Clara River (Figure 1), a Virgin River tributary, as early as 1863 (Miller 1961), with only a moderate divide separating Grass Valley at the upper end of the Santa Clara River drainage from the Bonneville basin. Residents of the area, which was settled in about 1855, thought the cutthroat trout occurred naturally

and were aware of rainbow trout being stocked after 1900. Conversely, it can be argued that if BCT occurred in this area naturally, it seems as if they should have been more widespread throughout the Virgin River drainage and noted in other early fish collections.

We found some evidence that supports BCT occurring naturally in the Virgin River drainage. J. D. Lee's diary noted that he caught many trout from the Santa Clara River in 1859 (Cleland and Brooks 1983). Judging from our BCT transplants, for trout to have become as abundant and widespread in the upper Santa Clara River as described for the years 1859 and 1863 (Miller 1961, Cleland and Brooks 1983) transplants would have had to have been made near or before the time that pioneers entered the Salt Lake Valley in northern Utah in 1847. Such an introduction seems unlikely. We also recently found a native Virgin River fish, the desert sucker (*Catostomus clarki*), in the Bonneville basin in this same general area, just across the drainage divide from the headwaters of Magotsu Creek, a Santa Clara River tributary. This is the only location in Utah where desert suckers have been found outside of the Virgin River drainage, and it raises the possibility that different species naturally moved in both directions between drainages.

The topography and geology of Grass Valley Creek provides evidence of natural stream piracy between two basins (C. F. Lohrengel, Geology Department Southern Utah University,

personal communication). During the existence of Lake Bonneville (>10,000 years ago) Grass Valley Creek probably was a tributary to Pinto Creek which, in turn, flowed into Lake Bonneville. Volcanic activity in this area within the last 2000 years probably diverted Grass Valley Creek into the Santa Clara River and the Virgin River drainage. Today, a downhill course can still be traced on contour maps from Grass Valley Creek to the South Fork of Pinto Creek. Area residents attempted to divert Grass Valley Creek into Pinto Creek via a ditch in about 1912, but the system was not maintained (Utah State Division of Water Rights, personal communication). In about 1922, a successful diversion through a tunnel was completed that is still functional. Although man-made diversions might have allowed BCT to move between drainages, water was not diverted in time to explain early reports of trout in the Santa Clara River.

If a natural transfer of trout occurred in recent geologic times, native trout might not have had time to expand within the Virgin River drainage beyond the Santa Clara River. Under current conditions, barriers would prevent upstream movement into most cold water habitats, and movements in lower elevations are inhibited by temperatures, turbidity, and unfavorable habitat. Several endemic fishes in the Virgin River are limited by similar barriers even though the fish evolved in the system and upstream habitat is available. Introductions of nonnative trouts by man soon after the turn of

the century would have further masked the invasion of BCT into the Santa Clara River system and prevented further expansion. In regard to present management, BCT appear to be the most appropriate trout for use in the Virgin River drainage and are likely native to at least the Santa Clara River portion of the drainage.

Recent history of BCT in Reservoir Canyon Creek is more clearly documented. Kumen Gardner, a rancher from Grass Valley, related to us in 1980 how he helped his older brother collect cutthroat trout from Grass Valley Creek by their house in approximately 1913 when he was about 12 years old. The fish were then loaded on horses and taken up the mountain and released into Reservoir Canyon, a headwater tributary to Grass Valley that had previously been devoid of fish. Grass Valley Creek was later stocked with rainbow trout, which are the predominant trout found in this location today, BCT in Reservoir Canyon remained isolated from nonnative trout in Grass Valley Creek by numerous waterfalls.

BCT from Water and Reservoir canyons are thought to be almost identical because both streams are neighboring tributaries to Grass Valley Creek, A mixed population of BCT from these streams was established in Leeds Creek and its tributaries (Table 1), recreating a situation somewhat similar to historical conditions in the Grass Valley area. BCT were transplanted to Leeds Creek after a wild fire decimated the existing rainbow trout population,

Cutthroat Trout Population Dynamics

Many factors influenced trout densities in both remnant and transplanted BCT populations. These included habitat quality, which was often determined by land management practices, and natural events such as droughts, floods, and fires. Many of the streams we surveyed were relatively small and the amount of trout habitat varied considerably with annual variations in stream flow. Much of lower Birch Creek, for example, contained marginal trout habitat which was caused by low flow and high water temperature. Surveys were conducted six times on Birch Creek since 1970 (Table 3). Estimated BCT densities generally exceeded 250 fish per km, with >10 km occupied during extended periods of high water. Following droughts in 1977 and the early 1990's (Utah Climate Center 1994), BCT density was generally <175 fish per km. In 1980, the population was confined to the upper 3 km or less of stream. Changes in land management (Bureau of Land Management 1976) have since improved trout habitat in Birch Creek and reduced impacts of recent drought. Even though the latest drought was more severe and of longer duration than the 1977 drought, a healthy population existed in >6 km of stream.

Effects of drought were even more dramatic at Water Canyon, where surveys were conducted following droughts in 1977, the late 1980's, and early 1990's (Table 3). BCT densities were very low. By late summer 1989, BCT were

restricted to <0.5 km of stream near the headwaters; the remainder was completely dry. Good water years occurred during the mid-1980's (Utah Climate Center 1994) and fish expanded into >3 km of stream. Formal surveys were not conducted in the mid-1980's, but we knew BCT numbers and range had increased greatly by our observations. In fact, we collected and transplanted >190 BCT from the lower portion of Water Canyon in 1986-1989 to establish populations in Leap, Spirit, and Pig Creeks. All BCT collected for transplants were taken from the lower 2 km of stream which had been dry in 1977. During our 1995 survey, BCT were still recovering from the drought that began in 1989 and were restricted to approximately 1 km of stream.

Fires, flash floods, and associated changes in water quality also have impacted BCT in southwestern Utah. Summer rainstorms following a 1986 wild fire in the Leeds Creek watershed severely reduced the rainbow trout population present at that time. The few surviving trout were found in springs and tributaries. Propst et al. (1992) reported a similar phenomenon following fire for Gila trout (O. gilae) in small streams in New Mexico. When BCT were introduced into Leeds Creek, they were placed in more of the tributaries and further upstream in headwater springs to reduce the chance of elimination by a future fire.

Duff (1988) reported that several transplanted groups of BCT were eliminated as a result of droughts and spring floods

in 1983-1984. This did not occur in southern Utah despite flooding, Spring floods caused habitat damage and reduced stream carrying capacity, but did not eliminate fish populations. BCT in Pine Creek (Table 3) successfully reproduced during the flood years and increased in total number following their recent introduction, although stream habitat was badly damaged. Stream conditions and potential carrying capacity afterwards improved from both natural processes and management efforts.

Another factor that influenced the density of BCT in newly established populations was the time between the original transplant and our sampling, Many of the new populations were still expanding and they probably had not reached carrying capacity, The number of BCT initially introduced and the distribution of introduction sites influenced the rate of population expansion. At Pine Creek, for example, where a relatively large number of fish were introduced at several sites, BCT were abundant throughout the stream within 4 years, At Sam Stowe Creek, in contrast, where a smaller number of BCT were introduced in the headwaters, BCT were not present in the lower reaches after 7 years. In all instances where BCT introductions were limited to headwater areas (Sam Stowe, Leap, South Ash, and Leeds creeks) downstream movement was slow, even when larger numbers of fish were transplanted. Fish were abundant in areas close to where they were released within a few years after introduction, but were often absent only a

short distance downstream.

Use of short term studies of fish populations to assess land management practices or build predictive models has been criticized for a number of reasons. Platts and Nelson (1988) found that trout populations in western streams, including some cutthroat populations in the Great Basin, exhibited large annual fluctuations. House (1995) reported that a wild coastal cutthroat population varied from year to year with no apparent changes in habitat conditions. Although we were limited to a single population estimate for many of the 'younger' transplanted populations, we had multiple-year estimates of density and biomass for a number of populations (Table 3). Also, we excluded Y-O-Y trout from our estimates as suggested by House (1995) to eliminate the variation inherent when including that age-group, and we did not limit our overall evaluation to formal survey data (see Methods).

MANAGEMENT IMPLICATIONS

In general, BCT habitat and status in southern Utah has improved since the late 1970's when conservation efforts began. Proposed recovery plans for the greenback cutthroat trout (O. c. stomias) from Colorado's east slope included establishing a minimum of 20 populations in 50 km of stream as part of the requirements to remove the subspecies from threatened status under the Endangered Species Act (U.S. Fish and Wildlife

Service 1983a). The Gila Trout Recovery Plan is more general, noting that down-listing to threatened would be considered when all known indigenous lineages are transplanted in the wild (U.S. Fish and Wildlife Service 1993). The Arizona Trout (Apache Trout) (Q. a<u>c h e</u>) Recovery Plan lists the establishment and/or maintenance of 30 discrete self-sustaining populations as a goal for delisting (U.S. Fish and Wildlife Service 1983b). In comparison, the number of BCT populations present in southern Utah, which represents only a portion of that subspecies' current range, is now approaching levels listed as objectives for the Southeastern management unit identified in the State of Utah's Conservation Agreement for BCT.

Most important, agency regulations and polices, along with state and federal laws, provide habitat protection that did not exist when BCT suffered dramatic population declines. Utah's conceptual management plan for cutthroat trout (Schmidt et al. 1995), federal land and resource management plans, interagency memorandums of understanding, and agency lists of species needing special attention all provide emphasis to help protect BCT. Most recently, the state of Utah in cooperation with the U.S. Fish and Wildlife Service and other agencies have developed a draft Conservation Agreement and Management Strategy for BCT. Furthermore, state and federal statues now require critical review of all projects which may impact the environment and provide protection for aquatic and riparian

habitats. Today, state fish and wildlife agencies have polices which prevent indiscriminate introductions of nonnative fishes. Whereas introductions of nonnative fish was probably the most important factor leading to BCT declines in the past, careful reviews, approvals, and records of even routine fish stockings are now required.

Eggs taken from wild brood stock at Manning Meadow Reservoir have reduced stocking of nonnative trouts in southern Utah. For the first time, enough BCT were raised in 1995 to replace Yellowstone cutthroat trout normally raised and stocked for sport fishing in the southern portion of the Bonneville basin. Having a large source of native trout available for sportfish management also allows introductions of native fish to be made into marginal areas where transplants of limited numbers of wild fish would not be risked. New introductions can also be made in areas with high sport fishing interest where native populations could not be established in short periods of time from small transplants.

Over-fishing in places like Utah Lake or Panguitch Lake may have hastened the decline of BCT in those locations. Nevertheless, angling has not been a threat to BCT populations in southern Utah during recent years. Many of the BCT streams are in remote locations and are difficult to fish. Most BCT are small and attract little attention from anglers. All populations we worked with can sustain some fish harvest as shown by the 1994-1995 surveys and the recovery of populations

following transplants. With the exception of Manning Meadow Reservoir, restrictive regulations or closures have not been necessary.

A limited season (July through December), restrictive methods (flies and lures only), and limited take (catch and release only) regulations were imposed at Manning Meadow Reservoir to protect BCT that were introduced as brood stock. This approach allowed the public to continue to fish in an area of high interest. Fishing regulations were relaxed in 1995 after numbers of BCT increased, allowing a possession limit of two fish.

One of the greatest problems with BCT management today is gaining environmental clearances and agency approvals to conduct field projects intended to benefit this fish. Opposition to BCT projects has developed because of potential listing under the Endangered Species Act and fears that projects will cause negative impacts on other interests and land uses. Behnke (1992) provided a warning in his epilogue about a potential "backlash" against the Endangered Species Act and cautioned about the need to prevent perceptions of "over-zealous" application of the act. It is ironic that some of the legislation and policies designated to protect native fishes are now becoming the stumbling blocks that limit on-the-ground projects. A balance needs to be achieved between over-rigorous agency emphasis of BCT management and such limited emphasis that appropriate plans and budgets are lost. The intent of

developing an interagency Conservation Agreement and Strategy, in part, is to resolve some of these problems and avoid the negative aspects of proposed federal listing.

Despite some regulatory and administrative problems, BCT are far less threatened in southern Utah today than they were 20 years ago. Although BCT are not as abundant as they were at the turn of the century, the trend since 1977 has been one of increasing abundance and expanding range.

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Table 1. Location and source of Bonneville cutthroat trout in southern Utah, 1973-1995 (adapted from Hepworth et al. 1997).

Reference number[a]	Drainage/ primary stream/ tributary	Land status[a]	Population source	Year identified or transplanted	Number transplanted	Donor stream[a]
	Sevier River drainage					
1	Deep Creek	DNF, BLM	Remnant	1982 [d,e]	-	-
2	Sam Stowe Creek	FNF, ST	Transplant	1977	39	BC
3	Threemile Creek	DNF, BLM	Transplant	1994	113	BC
	Delong Creek	DNF	Transplant	1994	30	BC
	Indian Hollow	DNF	Transplant	1994	30	BC
4	Manning Creek Reservoir	FNF, BLM, ST	Transplant	1990	714	PC
5	Ranch Creek	DNF, ST	Remnant	1995 [f]	-	-
	Beaver River drainage[b]					
6	Birch Creek	FNF, BLM	Remnant	1973 [c]	-	-
7	N. Fk. North Creek	FNF	Remnant	1982 [d]	-	-
	Pole Creek	FNF	Transplant	1995	35	NFC
8	Pine Creek	FNF, ST, PR	Transplant	1980	245	BC, RC, WC
9	Briggs Creek	UP, ST	Transplant	1988	100	BC
	Virgin River drainage					
10	Reservoir Canyon Creek	DNF	Remnant	1973 [c]	-	-
11	Water Canyon Creek	DNF	Remnant	1973 [c]	-	-
12	Leap Creek	DNF	Transplant	1986	72	WC
13	South Ash Creek	DNF	Transplant	1986	0	RC
	Harmon Creek	DNF	Transplant	1986	80	RC
	Mill Creek	DNF	Transplant	1986	118	RC
14	Leeds Creek	DNF	Transplant	1989	90	RC
	Pig Creek	DNF	Transplant	1989	60	RC, WC
	Spirit Creek	DNF	Transplant	1988	99	WC
	Horse Creek	DNF	Transplant	1995	35	SP

[a] Numbers refer to locations on Figure 1.
[b] The Beaver River drainage is a major subdrainage within the Sevier River drainage.
[c] DNF = Dixie National Forest, FNF = Fishlake National Forest, BLM = Bureau of Land Management, ST = state land, and PR = private land.
[d] Martin and Shiozawa (1982).
[e] Behnke (1976).
[f] Present study.
[g] BC = Birch Creek, NFC = North Fork Creek, RC = Reservoir Canyon, WC = Water Canyon, PC = Pine Creek, and SP = Spirit Creek.

Table 2. Stream lengths and abundance of Bonneville cutthroat trout in southern Utah, 1994-1995 (adapted from Hepworth et al. 1997).

Primary stream/tributary	Number of sections sampled (number in occupied habitat)	Average stream width (m)	Available km	Occupied km	Trout abundance in occupied habitat				Trout lengths (mm)	
					Number per km	Number per ha	Kg per km	Kg per ha	Mean	Range
Deep Creek	2 (2)	1.86	9.7	9.7	276	1484	9.1	49	150	94-218
Sam Stowe Creek [a]	3 (3)	1.43	4.8	4.8	306	2136	14.3	100	169	130-228
Threemile Creek	Introduction in 1994	1.31	8.8	b						
Delong Creek	Introduction in 1994		3.4	b						
Indian Hollow	Introduction in 1994		1.6	b						
Manning Creek	Treatment 1995		16.4	b						
Barney Outlet	Treatment 1995		2.1	b						
Collins Creek	Treatment in 1995		2.1	b						
Vale[illegible]	Treatment in 1995		1.9	b						
Ranch Creek	2 (2)	1.04	11.7	4.5	171	1657	5.5	53	148	80-244
Birch Creek	4 (3)	1.19	8.8	6.8	160	1351	5.0	42	146	105-232
N. Fk. North Creek	6 (2)	2.59	8.8	3.2	214	827	90	36	163	106-234
Pole[illegible]	Introduction in 1995		4.3	b						
Pine Creek	3 (3)	1.86	6.3	6.3	228	1225	5.0	27	131	77-222
Briggs Creek	2 (2)	1.55	1.4	1.0	124	797	5.6	36	166	85-236
Reservoir Canyon Creek	2 (2)	2.35	3.2	3.2	546	2336	12.0	51	130	73-225
Water Canyon Creek	3 (1)	1.98	3.2	0.8	118	595	1.7	8	112	76-183
Leap Creek	4 (2)	1.80	8.8	2.7	130	721	5.6	31	163	92-256
South Ash Creek	3 (2)	3.32	6.0	4.0	189	570	8.9	27	169	112-259
Harmon Creek	2 (2)	2.71	[illegible]	1.8	174	639	8.5	31	171	83-265
Mill Creek	2 (2)	3.11	7.4	5.1	252	807	8.6	27	151	81-214
Leeds Creek	3 (2)	2.71	11.3	4.8	254	973	16.3	60	185	98-257
Pig Creek	1 (1)	1.34	1.6	1.6	230	1723	7.1	53	147	77-249
Spirit Creek	2 (2)	1.46	3.5	1.18	261	1788	9.4	64	154	68-305
Horse Creek	Introduction in 1995	-	3.4	b	-	-	-	-	-	-

[a] Bonneville cutthroat trout hybridized with rainbow trout.
[b] Limited occupied habitat because fish were recently introduced.

Table 3. Current abundance (1994-1995) of southern Utah Bonneville cutthroat trout compared to previous years (from Hepworth et al. 1977).

Population (source)	Year	Number of trout per km (number survey stations)		
		Upper Stream	Middle Stream	Lower Stream
Deep Creek (remnant)	1980	-	161 (1)	-
	1995	-	435 (1)	118 (1)
Birch Creek (remnant)	1970	404 (1)	-	186 (1)
	1974	385 (1)	248 (1)	-
	1975	230 (1)	342 (1)	-
	1980	161 (1)	0 (1)	0 (1)
	1987	-	335 (1)	-
	1994	155 (1)	174 (1)	149 (1)
N. Fk. North Creek (remnant)	1970	273 (1)	-	-
	1981	56 (1)	-	-
	1994	214 (2)	0 (2)	0 (2)
Reservoir Canyon (remnant)	1980	397 (1)	-	-
	1995	540 (1)	553 (1)	-
Water Canyon Creek (remnant)	1980	37 (1)	99 (1)	12 (1)
	1995	118 (1)	0 (1)	0 (1)
Sam Stowe Creek (transplant)	1980	174 (1)	0 (1)	-
	1984	422 (1)	25 (1)	-
	1995[a]	422 (1)	292 (1)	205 (1)
Pine Creek (transplant)	1982	130 (1)	75 (1)	168 (1)
	1984	-	298 (2)	248 (1)
	1994	180 (1)	230 (1)	273 (1)
Leep Creek (transplant)	1989	304 (1)	-	-
	1994	-	0 (1)	0 (2)
	1995	130 (2)	-	-

[a]Bonneville cutthroat trout hybridized with rainbow trout.

Table 4. Abundance, biomass, and total length compared between Bonneville cutthroat trout and rainbow trout in two southern Utah streams (samples were &om different time periods but from the same *survey* locations) (from Hepworth et al. 1977).

Stream	Species/year	Number per km	Kg per km	Mean length mm (n)
Leap Creek	Rainbow trout 1983	360	11.8	130 (29)
	Cutthroat trout 1989	304	2.5	96 (25)
	Cutthroat trout 1995	130	5.6	163 (41)
Leeds Creek	Rainbow trout 1980	646	29.6	152 (52)
	Cutthroat trout 1995	193	1.2.4	188 (28)

Table 5. Important land management actions that increased protection of Bonneville cutthroat or improved *stream* habitat in southern Utah, 1977-1995 (X indicates actions implemented).

Primary stream/tributary	Management action					
	Instream structures	Fencing	Road closures	Road relocation	Fish barrier	Land resource management designation
Deep Creek						
Sam Stowe Creek	X	X	X		X	X
Threemile Creek	X	X			X	X
Delong Creek						
Indian Creek						
Manning Creek					X	X
Birch Creek	X	X	X		X	X
N. Fk. North Creek	X	X			X	X
Pole Creek						
Pine Creek	X	X		X		X
Briggs Creek						
Reservoir Canyon Creek						X
Water Canyon Creek	X	X		X		X
Leap Creek			X			X
South Ash Creek						X
Harmon Creek						X
Mill Creek						X
Leeds Creek						X
Pig Creek						
spirit Creek						
Horse Creek						

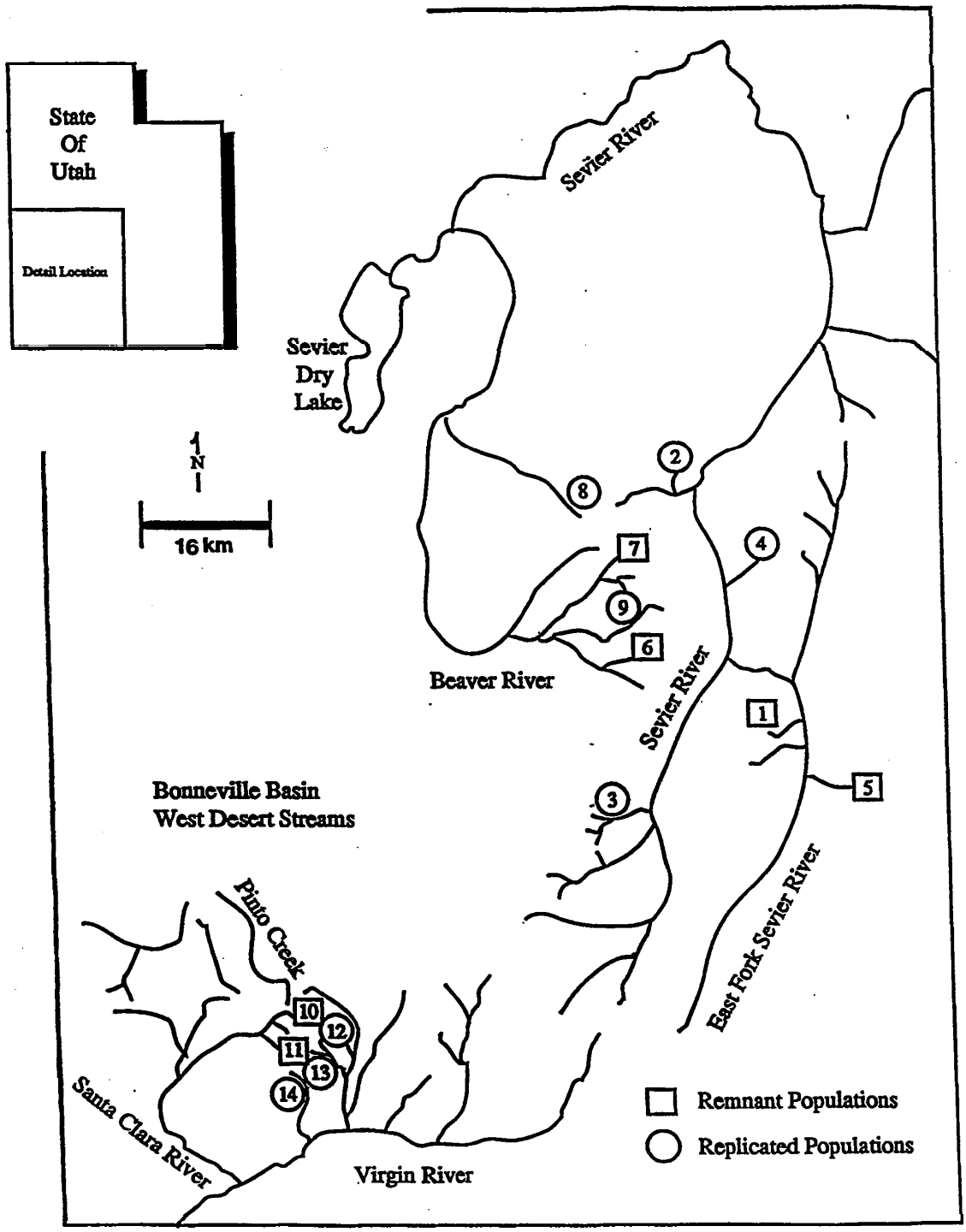

Figure 1. Map of the Sevier, Beaver, and Virgin river drainages (from Hepworth et al. 1997). Reference numbers correspond to primary streams containing Bonneville cutthroat trout as listed in Table 1.